LHC Z' discovery potential for models with continuously distributed mass

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Abstract

We study the Large Hadron Collider (LHC) discovery potential for Z' models with continuously distributed mass for $\sqrt{s} = 7,\ 10$ and $14\ TeV$ centre-of-mass energies. One of possible LHC signatures for such models is the existence of broad resonance structure in Drell-Yan reaction $pp \to Z' + ... \to l^+l^- + ...$.

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The search for new vector $Z^`$ bosons [1] is one of the most important goals of the Large Hadron Collider (LHC). The LHC $Z^`$ boson discovery potential at CMS and ATLAS detectors has been studied for narrow $Z^`$ resonances in refs.[2, 3]. The $Z^`$ models with broad resonance structure naturally arise in the context of $Z^`$ models with continuously distributed masses [4, 5]. Note that recent notion of unparticle introduced by Georgi [6] (unparticle phenomenology is discussed in refs.[7]) can be interpreted as a particular case of a field with continuously distributed mass [4, 5, 8, 9, 10, 11]. Also scenario with large invisible decay width can be realized if $Z^`$ boson couples to neutral leptons and decays mainly into heavy neutral leptons.

In this paper we present the LHC discovery potential for the $Z^`$ models with continuously distributed mass for $\sqrt{s} = 7,\ 10$ and $14\ TeV$ centre-of-mass energies. [1]

Consider the Stueckelberg Lagrangian [13]

$$L_0 = \sum_{k=1}^{N} [-\frac{1}{4} F^{\mu\nu,k} F_{\mu\nu,k} + \frac{m_k^2}{2} (A_{\mu,k} - \partial_\mu \phi_k)^2]\,, \tag{1}$$

where $F_{\mu\nu,k} = \partial_\mu A_{\nu,k} - \partial_\nu A_{\mu,k}$. The Lagrangian (1) is invariant under gauge transformations

$$A_{\mu,k} \rightarrow A_{\mu,k} + \partial_\mu \alpha_k\,, \tag{2}$$

$$\phi_k \rightarrow \phi_k + \alpha_k \tag{3}$$

and it describes N free massive vector fields with masses m_k. For the field $B_\mu = \sum_{k=1}^{N} c_k A_{\mu,k}$ the propagator in transverse gauge is

$$D_{\mu\nu}(p) = (g_{\mu\nu} - \frac{p_\mu p_\nu}{p^2})(\sum_{k=1}^{N} \frac{|c|_k^2}{p^2 - m_k^2})\,. \tag{4}$$

In the limit $N \rightarrow \infty$

$$D_{\mu\nu}(p) \rightarrow (g_{\mu\nu} - \frac{p_\mu p_\nu}{p^2}) D_{int}(p^2)\,, \tag{5}$$

where

$$D_{int}(p^2) = \int_0^\infty \frac{\rho(t)}{p^2 - t + i\epsilon} dt \tag{6}$$

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[1]In recent papers [12] the LHC $Z^`$ boson discovery potential was studied for energies $\sqrt{s} = 7,\ 10$ and $14\ TeV$.

and $\rho(t) = lim_{N\to\infty} |c_k^2| \delta(t - m_k^2) \geq 0$.

The fields with continuously distributed masses arise naturally in d-dimensional field theories [4]. Consider the 5 -dimensional extension of the Stueckelberg Lagrangian (1), namely:

$$L_5 = -\frac{1}{4} F^{\mu\nu}(x, x_4) F_{\mu\nu}(x, x_4) + \frac{1}{2} ((A_\mu(x, x_4) - \partial_\mu \Phi(x, x_4)) f(-\partial_4^2)(A^\mu(x, x_4) - \partial^\mu \Phi(x, x_4)), \tag{7}$$

where $F_{\mu\nu}(x, x_4) = \partial_\mu A_\nu(x, x_4) - \partial_\nu A_\mu(x, x_4)$, $\partial_4 = \frac{\partial}{\partial x_4}$, $x = (x^0, x^1, x^2, x^3)$; $\mu, \nu = 0, 1, 2, 3$. The Lagrangian (7) is invariant under gauge transformations

$$A_\mu(x, x_4) \rightarrow A_\mu(x, x_4) + \partial_\mu \alpha(x, x_4), \tag{8}$$

$$\Phi(x, x_4) \rightarrow \Phi(x, x_4) + \alpha(x, x_4). \tag{9}$$

Note that the Lagrangian (7) for arbitrary function $f(-\partial_4^2)$ is invariant only under four-dimensional Poincare group. For the Lagrangian (7) the propagator for the vector field $A_\mu(x, x_4)$ in transverse gauge is

$$D_{\mu\nu}(p, p_4) = (g_{\mu\nu} - \frac{p_\mu p_\nu}{p^2}) \frac{1}{p^2 - f(p_4^2) + i\epsilon}, \tag{10}$$

where $p^2 \equiv p^\mu p_\mu$. The propagator for the four-dimensional vector field $A_\mu(x, x_4 = 0)$ in transverse gauge has the form

$$D_{\mu\nu}(p) = (g_{\mu\nu} - \frac{p_\mu p_\nu}{p^2}) \frac{1}{2\pi} \int_{-\infty}^{+\infty} dp_4 \frac{1}{p^2 - f(p_4^2) + i\epsilon} = \int_0^\infty dt \frac{\rho(t)}{p^\mu p_\mu - t + i\epsilon}, \tag{11}$$

where

$$\rho(t) = \frac{1}{\pi} \frac{d\sqrt{f^{(-1)}(t)}}{dt}, \tag{12}$$

where $f(f^{-1}(t)) = t$.

Consider the interaction of the five-dimensional field $A_\mu(x, x_4)$ with the four-dimensional fermion field $\psi(x)$ in the form

$$L_{int} = g\bar{\psi}(x)\gamma^\mu \psi(x) A_\mu(x, x_4 = 0). \tag{13}$$

In our model vector field $A_\mu(x, x_4)$ lives in five-dimensional space-time whereas other matter fields (quarks, leptons ..) live in standard five-dimensional field. [2] The Feynman rules

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[2] The model (13) is similar to ADD model [14] in which gravity lives in $(d > 4)$ space-time whereas other matter fields live in four-dimensional space-time.

for the model (13) coincide with standard Feynman rules for QED except the replacement of photon propagator

$$\frac{1}{p^2 + i\epsilon} \rightarrow \int_0^{+\infty} \frac{\rho(t)dt}{p^2 - t + i\epsilon} \,, \tag{14}$$

Note that considered model as the uncompactified ADD model is unitary only in 5-dimensional space-time since vector fields $A_\mu(x, x_4)$ propagates in 5-dimensional space-time.

As an example we consider the spectral density $\rho(t)$ of the Breit-Wigner type. The following approximate relation takes place:

$$\frac{1}{p^2 - m^2 + im\Gamma} \approx \int_0^\infty \frac{\rho(t)dt}{p^2 - t + i\epsilon} \,, \tag{15}$$

where

$$\rho(t) = \frac{1}{\pi} \frac{\Gamma m}{(t - m^2)^2 + \Gamma^2 m^2} \,. \tag{16}$$

As it follows from the equalities (15,16) we can consider vector particle with continuously distributed mass as a particle with some internal decay width Γ into additional dimension.
[3]

In most standard $Z^{`}$ models [1] the total decay width $\Gamma_{tot}$ is rather narrow. Typically $\Gamma_{tot} \leq O(10^{-2}) \cdot m_{Z^{`}}$. It should be noted that the interaction of $Z^{`}$ boson with additional neutral fermions increases invisible $Z^{`}$ decay width and can lead to large total decay width of the $Z^{`}$ boson. One can introduce the interaction of the field B_μ with quark and lepton fields in a standard way as

$$L_{int} = J_\mu B^\mu \,, \tag{17}$$

where

$$J_\mu = \sum_k [g_{kL}\bar{q}_L \gamma_\mu q_L + g_{kR}\bar{q}_R \gamma_\mu q_R + g_{lL}\bar{l}_L \gamma_\mu l_L + g_{lR}\bar{l}_R \gamma_\mu l_R] \,. \tag{18}$$

The Feynman rules for this model coincide with Feynman rules for standard $Z^{`}$ model except the replacement of the standard vector $Z^{`}$ boson propagator

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[3]Note that in RS 2 model [15] massive particles initially located on our brane may leave the brane and disappear into extra dimensions [16].

$$D_{\mu\nu}^{tr}(p) = (g_{\mu\nu} - \frac{p_\mu p_\nu}{p^2})\frac{1}{p^2 - m_{Z^{'}}^2} \to (g_{\mu\nu} - \frac{p_\mu p_\nu}{p^2})D_{int}(p^2)\,, \tag{19}$$

$$D_{int}(p^2) = \int_0^\infty \frac{\rho(t)dt}{p^2 - t + i\epsilon}\,, \tag{20}$$

This generalization preserves the renormalizability for finite $\int_0^\infty \rho(t)dt$ because the ultraviolet asymptotic of $D_{int}(p^2)$ coincides with free $Z^{'}$ boson propagator asymptotic $\frac{1}{p^2}$ [4].

In this paper we consider three Z' models. In model A the $Z^{'}$ boson interaction with quarks and leptons is the same as for standard Z boson. In model B the interaction of $Z^{'}$ boson with quark and lepton fields is determined by the current

$$J_\mu = \frac{g}{2}[\sum_{q,l}(\bar{q}\gamma_\mu(1+\gamma_5)q + \bar{l}\gamma_\mu(1+\gamma_5)l]\,, \tag{21}$$

where $g = 0.65$ is the Standard Model $SU(2)_L$ coupling constant. [5] In model C the $Z^{'}$ boson interacts with (B-L) current

$$L_{mu} = g_{B-L}\sum_{q,l}[\frac{1}{3}\bar{q}\gamma_\mu q - \bar{l}\gamma_\mu l] \tag{22}$$

with coupling constant $g_{B-L} = 0.9$.

For standard $Z^{'}$ boson the matrix element of the Drell-Yan reaction at quark-parton level $q\bar{q} \to Z^{'} \to l^+l^-$ is proportional to

$$M(q\bar{q} \to Z^{'} \to l^+l^-) \sim \frac{1}{s - M_{Z^{'}}^2 + i\Gamma_{tot}M_{Z^{'}}}\,, \tag{23}$$

where Γ_{tot} is total decay width of the $Z^{'}$ boson. For our model with free vector propagator (7,8) the matrix element is proportional to

$$M(q\bar{q} \to Z^{'} \to l^+l^-) \sim \frac{1}{s - M_{Z^{'}}^2 + i\Gamma_{tot}M_{Z^{'}} + i\Gamma M_{Z^{'}}}\,. \tag{24}$$

The difference between our model and standard case consists in the replacement $\Gamma_{tot} \to \Gamma_{tot} + \Gamma$. It means that our model is equivalent to standard $Z^{'}$ model with additional

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[4]Note that for $\rho(t) \sim t^{\delta-1}$ we reproduce the case of vector unparticle with propagator $\sim \frac{1}{(p^2)^{1-\delta}}$.

[5]Model B has γ_5-anomaly. By the introduction of additional neutral fermions it is possible to get rid of γ_5-anomalies. At any rate we consider model B as a toy model.

invisible decay width Γ. This fact allows to use standard simulation code PYTHIA [17]. To make the invisible $Z^`$ resonance decay width $\Gamma$ at the PYTHIA level we modified the $Z^`$ boson interaction with the first flavor of neutrino, namely we made the replacement

$$Z_\mu^` g_\nu \bar\nu(\gamma_\mu + \gamma_\mu\gamma_5)\nu \rightarrow Z_\mu^` g_\nu \bar\nu(\gamma_\mu(1+u) + \gamma_\mu\gamma_5(1-u))\nu,$$

where u is some parameter. The parameter $u = 0$ corresponds to the case of standard interaction and the invisible decay width into right-handed neutrino is proportional to $|u|^2$ and for large u invisible decay width dominates. In other words, we introduced additional interaction of the $Z^`$ boson with right-handed neutrino that allows to make the $Z^`$ boson rather wide. [6] The values of total decay width Γ_{tot} for some parameters u for models A, B and C are given in Table 1.

The reaction we are interested in is di-lepton production

$$pp \rightarrow \gamma^*, Z^*, Z^{`*} + ... \rightarrow l^+l^- + ...$$

Here $l = e, \mu$. The main background is the Drell-Yan production $PP \rightarrow \gamma^*, Z^* + ... \rightarrow l^+l^- + ...$ Other backgrounds like WW, ZZ, WZ or $t\bar{t}$ are small. For leptons standard acceptance cuts are the following:

$$p_T^l > 10 \; GeV \,, \tag{25}$$

$$|\eta^l| < 2.4 \,. \tag{26}$$

For di-lepton invariant mass M_{ll} we apply cut

$$M_{ll} > M_{Z^`} \,. \tag{27}$$

This cut differs from standard cut

$$|M_{ll} - M_{Z^`}| < \frac{\Gamma_{Z^`}}{2} \tag{28}$$

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[6]For large parameter u the coupling constant $g_{\nu_R}u$ of the interaction $Z^`$ boson with right-handed neutrino is large that leads to the existence of Landau pole singularity for the effective charge at TeV energies and hence to the breakdown of unitarity at least within perturbation theory. However in the $Z^`$ models with continuously distributed mass we don't have these problems. We introduce the artificial interaction with right-handed neutrino in order to obtain the large $Z^`$ invisible decay width at the PYTHIA level.

often used for the estimation of the LHC $Z^{`}$ boson discovery potential for standard case of narrow $Z^{`}$ boson. The reason is that the Drell-Yan cross section is sharply decreasing function on M_{ll} and for wide $Z^{`}$ boson the Drell-Yan background dominates in mass region $M_{Z^{`}} - \frac{\Gamma_{Z^{`}}}{2} < M_{ll} < M_{Z^{`}}$. In our calculations we use PYTHIA 6.3 code [17] with STEQ6L [18] parton distribution functions evaluated at the scale $Q^2 = M_{Z^{`}}^2$. We did not take into account K-factors. An account of K-factor which is similar for both background and signal leads to the increase of significance. Also we don't take into account detector effects like effectiveness of electron or muon registration but at the CMS and ATLAS detectors the effectiveness of lepton registration is typically greater than 80 percent [2, 3] that can decrease significance by factor ≥ 0.8. An account of nonzero K-factor partly compensates this decrease. For the LHC total energy $\sqrt{s} = 14\ TeV$ and for $Z^{`}$ boson masses $1\ TeV \leq M_{Z^{`}} \leq 4\ TeV$ K-factor for both signal and background is approximately 1.3 - 1.4 [2]. An account of K-factor leads to the increase of the significance by factor $\sqrt{K} \approx 1.1 - 1.2$. For the estimation of the significance we use the method [19] based on frequentist approach which for the case of large statistics ($N_S \gg 1, N_B \gg 1$) leads to the approximate formula $S = 2(\sqrt{N_S + N_B} - \sqrt{N_B})$ for significance.

The first two years LHC will work with center-of-mass energy $\sqrt{s} = 7\ TeV$ and with total integrated luminosity $L_{tot} = O(1)\ fb^{-1}$. Finally the energy will be increased up to $\sqrt{s} = 14\ TeV$. In our estimates we use total integrated luminosity $L_{tot} = 1\ fb^{-1}$ for energies $\sqrt{s} = 7\ TeV,\ 10\ TeV$ and $L_{tot} = 100\ fb^{-1}$ for the LHC energy $\sqrt{s} = 14\ TeV$. For models A, B and C we studied the $Z^{`}$ bosons with total decay widths shown in Table 1. Our results are summarized in Tables 2-10.

Table 1. The ratio $\frac{\Gamma_{Z^{`},tot}}{M_{Z^{`}}}$ for models A,B,C and parameters $u = 0, 3, 5, 10, 15, 20$.

u-parameter	$\frac{\Gamma_{Z',tot}}{M_Z}$(mod.A)	$\frac{\Gamma_{Z',tot}}{M_Z}$(mod.B)	$\frac{\Gamma_{Z',tot}}{M_Z}$(mod.C)
$u = 0$	0.031	0.046	$6.2 \cdot 10^{-3}$
$u = 3$	0.048	0.062	0.028
$u = 5$	0.078	0.092	0.061
$u = 10$	0.22	0.23	0.21
$u = 15$	0.45	0.47	0.45
$u = 20$	0.78	0.79	0.79

Table 2. The LHC cross sections for signal plus background in fb and significances (in brackets) for total energy $\sqrt{s} = 7\ TeV$ and $M_{Z'} = 1\ TeV$. The background cross section is $\sigma_B = 1.9\ fb$ and total integrated luminosity is $L_{tot} = 1\ fb^{-1}$.

u-parameter	model A	model B	model C
$u = 0$	94 (17)	166 (23)	24 (7.3)
$u = 3$	58 (13)	114 (18)	5.8 (2.7)
$u = 5$	36 (6.2)	72 (14)	3.2 (1.7)
$u = 10$	12 (4.7)	20 (6.5)	non detectable
$u = 15$	5.6 (2.7)	7.2 (3.2)	non detectable
$u = 20$	3.6 (1.8)	5.2 (2.5)	non detectable

Table 3. The LHC cross sections for signal plus background in fb and significances (in brackets) for total energy $\sqrt{s} = 7\ TeV$ and $M_{Z'} = 1.2\ TeV$. The background cross section is $\sigma_B = 0.68\ fb$ and total integrated luminosity is $L_{tot} = 1\ fb^{-1}$.

u-parameter	model A	model B	model C
$u = 0$	47 (12)	83 (16)	12 (5.2)
$u = 3$	29 (9.0)	57 (13)	2.9 (1.9)
$u = 5$	18 (6.2)	36 (10)	1.6 (1.2)
$u = 10$	6 (3.3)	10 (4.6)	non detectable
$u = 15$	2.8 (1.9)	3.6 (2.3)	non detectable
$u = 20$	1.8 (1.3)	2.6 (1.8)	non detectable

Table 4. The LHC cross sections for signal plus background in fb and significances (in brackets) for total energy $\sqrt{s} = 10\ TeV$ and $M_{Z^\cdot} = 1.2\ TeV$. The background cross section is $\sigma_B = 2.2\ fb$ and total integrated luminosity is $L_{tot} = 1\ fb^{-1}$.

u-parameter	model A	model B	model C
$u = 0$	102 (17)	176 (24)	26 (7.3)
$u = 3$	66 (13)	124 (19)	6.4 (2.8)
$u = 5$	40 (10)	81 (15)	3.6 (1.8)
$u = 10$	13.6 (4.9)	24 (7.1)	non detectable
$u = 15$	6.6 (3.0)	8.4 (3.5)	non detectable
$u = 20$	4 (2.0)	4.1 (2.0)	non detectable

Table 5. The LHC cross sections for signal plus background in fb and significances (in brackets) for total energy $\sqrt{s} = 10\ TeV$ and $M_{Z^\cdot} = 1.5\ TeV$. The background cross section is $\sigma_B = 0.66\ fb$ and total integrated luminosity is $L_{tot} = 1\ fb^{-1}$.

u-parameter	model A	model B	model C
$u = 0$	34 (10)	58 (14)	8.8 (4.5)
$u = 3$	22 (7.8)	40 (11)	2.1 (1.6)
$u = 5$	13 (5.6)	26 (8.7)	non detectable
$u = 10$	4.2 (2.8)	7.8 (4.2)	non detectable
$u = 15$	2.0 (1.5)	2.6 (2.0)	non detectable
$u = 20$	non detectable	undetectable	non detectable

Table 6. The LHC cross sections for signal plus background in fb and significances (in brackets) for total energy $\sqrt{s} = 10\ TeV$ and $M_{Z^\cdot} = 1.8\ TeV$. The background cross section is $\sigma_B = 0.28\ fb$ and total integrated luminosity is $L_{tot} = 1\ fb^{-1}$.

u-parameter	model A	model B	model C
$u = 0$	11 (5.6)	20 (8.0)	non detectable
$u = 3$	22 (7.8)	19 (7.8)	non detectable
$u = 5$	8.6 (4.8)	15 (6.3)	non detectable
$u = 10$	3.2 (2.7)	6.4 (4.1)	non detectable
$u = 15$	non detectable	2.8 (1.7)	non detectable
$u = 20$	non detectable	non detectable	non detectable

Table 7. The LHC cross sections for signal plus background in fb and significances (in brackets) for total energy $\sqrt{s} = 14\ TeV$ and $M_{Z'} = 1.5\ TeV$. The background cross section is $\sigma_B = 2.0\ fb$ and total integrated luminosity is $L_{tot} = 100\ fb^{-1}$.

u-parameter	model A	model B	model C
$u = 0$	82 (151)	154 (219)	22 (69)
$u = 3$	78 (147)	138 (206)	5.2 (25)
$u = 5$	60 (126)	106 (175)	3.2 (17)
$u = 10$	26 (73)	48 (110)	1.1 (13)
$u = 15$	13 (41)	22 (65)	0.48 (6.1)
$u = 20$	7.0 (25)	11 (37)	.056 (3.7)

Table 8. The LHC cross sections for signal plus background in fb and significances (in brackets) for total energy $\sqrt{s} = 14\ TeV$ and $M_{Z'} = 2\ TeV$. The background cross section is $\sigma_B = 0.44\ fb$ and total integrated luminosity is $L_{tot} = 100\ fb^{-1}$.

u-parameter	model A	model B	model C
$u = 0$	22 (80)	28 (110)	5.8 (36)
$u = 3$	19 (75)	36 (107)	1.3 (13)
$u = 5$	15 (63)	26 (89)	0.72 (8.3)
$u = 10$	6.2 (37)	11 (53)	0.48 (5.9)
$u = 15$	2.8 (20)	5.0 (31)	0.098 (3.2)
$u = 20$	1.6 (12)	2.4 (18)	non detectable

Table 9 .The LHC cross sections for signal plus background in fb and significances (in brackets) for total energy $\sqrt{s} = 14\ TeV$ and $M_{Z'} = 3\ TeV$. The background cross section is $\sigma_B = 0.040\ fb$ and total integrated luminosity is $L_{tot} = 100\ fb^{-1}$.

u-parameter	model A	model B	model C
$u = 0$	2.0 (24)	3.6 (32)	0.54 (11)
$u = 3$	1.9 (23)	3.4 (31)	0.12 (4.0)
$u = 5$	1.4 (20)	2.6 (28)	0.064 (2.4)
$u = 10$	0.54 (11)	1.0 (17)	non detectable
$u = 15$	0.24 (5.6)	0.46 (9.4)	non detectable
$u = 20$	0.13 (3.2)	0.22 (5.4)	non detectable

Table 10. The LHC cross sections for signal plus background in fb and significances (in brackets) for total energy $\sqrt{s} = 14\ TeV$ and $M_{Z'} = 3.5\ TeV$. The background cross section is $\sigma_B = 0.040\ fb$ and total integrated luminosity is $L_{tot} = 100\ fb^{-1}$.

u-parameter	model A	model B
$u = 0$	0.68 (14)	1.18 (19)
$u = 3$	0.60 (13)	1.12 (18)
$u = 5$	0.48 (11)	0.88 (16)
$u = 10$	0.18 (6.4)	0.36 (10)
$u = 15$	0.08 (3.6)	0.14 (5.4)
$u = 20$	0.042 (2.2)	0.070 (3.3)

As we can see from Tables 2-10 the LHC discovery potential depends rather strongly on the total decay width and it decreases with the increase of the total decay width. The reason is trivial and it is due to the dilution factor $k = \frac{\Gamma_{tot}(u=o)}{\Gamma_{tot}(u=0)+\Gamma_{inv}(u)}$. Besides the LHC discovery perspectives are the best for the model B and the worst for the model C. The reason is that the number of signal events is proportional to σBr and it is maximal for model B and minimal for model C (in model C the coupling constant of the Z' interaction with quarks is small in comparison with models A and B).

Note that direct Tevatron experimental bound on the mass of $Z^{'}$ boson depends on the $Z^{'}$ model and for $Z^{'}$ boson with standard couplings $M_{Z^{'}} > 923\ GeV$ [20]. The existing experimental bounds on Stueckelberg $Z^{'}$ bosons were studied in ref.[21]. The very narrow Stueckelberg $Z^{'}$ boson can be discovered at Tevatron up to a mass about $600\ GeV$ with a total integrated luminosity of $8fb^{-1}$ [21].[7] For considered $Z^{'}$ models with large invisible decay width the Tevaton bound will be more weak for wide $Z^{'}$ bosons.

To conclude in this paper we studied the LHC discovery potential for $Z^{'}$ models with continuously distributed mass. One of the possible LHC signatures for such models is the existence of broad resonance structure in Drell-Yan reaction

$$pp \to Z^{'} + ... \to l^{+}l^{-} + ...$$

. We made our estimates at the parton level and did not take into account detector level [8]. Rough estimates show that detector effects are not very essential and will lead to the decrease of the significance by factor $0.8 - 0.9$. An account of K-factor partly compensates this decrease. The LHC discovery potential for wide $Z^{'}$ bosons is more weak than for the case of narrow $Z^{'}$ bosons due to the dilution factor for $Br(Z^{'} \to l^{+}l^{-})$. Nevertheless for some models it is possible to detect wide $Z^{'}$ bosons for masses up to $3 - 4\ TeV$ at final LHC energy $\sqrt{s} = 14\ TeV$ and total integrated luminosity $L_{tot} = 100\ fb^{-1}$. For the 2010-2011 LHC energy $\sqrt{s} = 7\ TeV$ and total integrated luminosity $L_{tot} = 1\ fb^{-1}$ it is possible to discover wide $Z^{'}$ boson with masses up to 1.2 TeV.

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[7]LHC discovery perspectives for Stueckelberg $Z^{'}$ bosons were studied in ref.[22].

[8]An account of detector effects will be given elsewhere [23].

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